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Occurrence of Fecal Coliform Bacteria in the Cheney Reservoir Watershed, South-Central Kansas, 1996–98

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The sanitary quality of water and its use as a public-water supply and for recreational activities, such as swimming, wading, boating, and fishing, can be evaluated on the basis of fecal coliform bacteria. The presence of fecal coliform bacteria indicates contamination by fecal material of human and (or) animal origin and the possible presence of pathogenic microorganisms. The purpose of this fact sheet is to describe the overall sanitary quality of surface water in the Cheney Reservoir watershed, compare and contrast subwatershed areas, and evaluate these areas relative to State water-quality criteria for fecal coliform bacteria.

Introduction

Cheney Reservoir, located in south-central Kansas (fig. 1), is a multiple-use reservoir that provides municipal water supplies for the city of Wichita and water for wildlife and recreation. Maintaining acceptable surface-water quality is important because poor surface-water quality may be detrimental to human health, may have adverse effects on fish populations and other aquatic organisms, and may interfere with the natural life cycles of both plants and animals that rely on surface water for their growth and reproduction.

Because the city of Wichita relies on water withdrawn from the reservoir for approximately 50 percent of its drinking-water supply (Jerry Blain, city of Wichita, Kansas, Water and Sewer Department, oral commun., 1999), the city has a long-term interest in maintaining acceptable water quality in Cheney Reservoir. The city recognizes that the quality of water in the reservoir may be directly linked to the quality of streams in its watershed. The city's interest in Cheney Reservoir watershed includes (1) defining surface-water-quality conditions in the watershed (concentrations and mass transport of selected constituents) and (2) providing economic assistance to the residents of the watershed for implementation of drainage-control structures and improved management practices (Jerry Blain, city of Wichita, Kansas, Water and Sewer Department, oral commun., 1999). This second area of interest is coordinated through the efforts of the Citizen's Management Committee established to serve as a liaison between the city and landowners and to identify those areas where economic assistance may produce the greatest water-quality benefit (Jerry Blain, city of Wichita, Kansas, Water and Sewer Department, oral commun., 1999).

A lack of historic water-quality data within the watershed led to a cooperative agreement in 1996 between the U.S. Geological Survey and the city of Wichita, with technical assistance provided by the Bureau of Reclamation, U.S. Department of the Interior, to define surface-water quality in the Cheney Reservoir watershed (Pope and Christensen, 1997). Many constituents, including fecal coliform bacteria, were analyzed at six sampling sites (fig. 1, table 1) to evaluate water-quality conditions within the watershed.

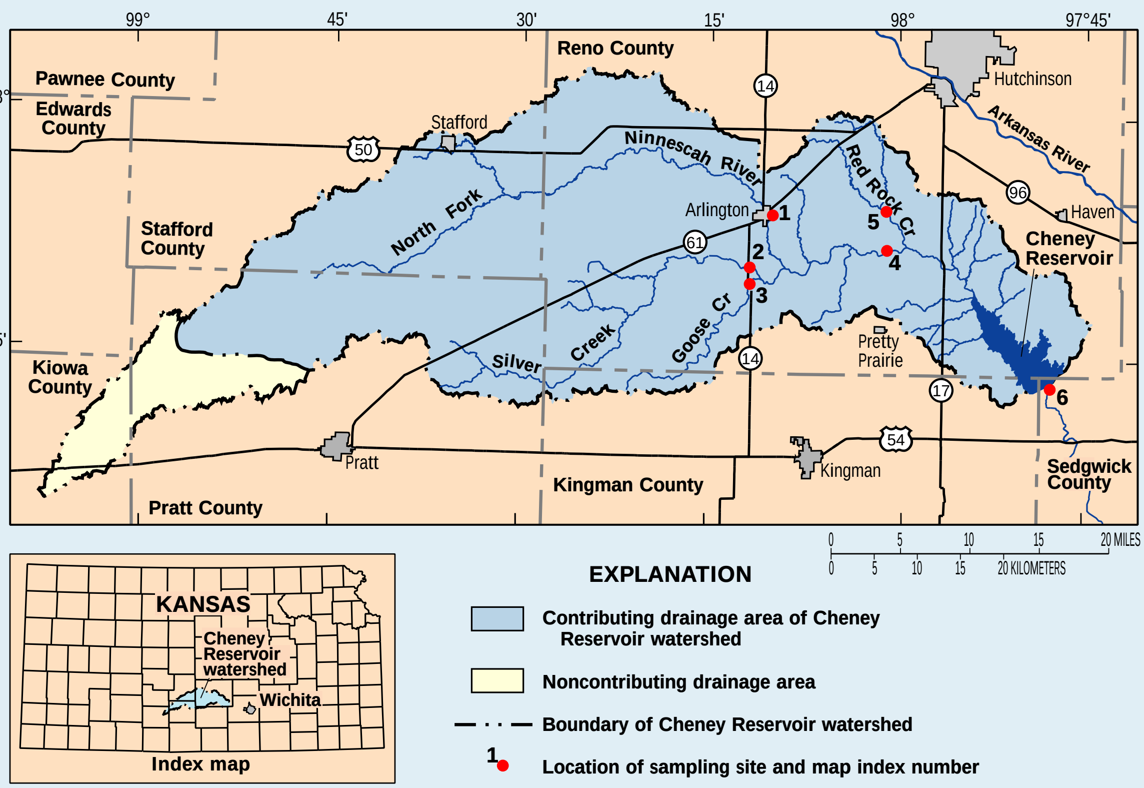

Figure 1. Location of Cheney Reservoir watershed in south-central Kansas and sampling sites used in this study.

Table 1. Description of sampling sites in the Cheney Reservoir watershed

Map index number (fig. 1)	U.S. Geological Survey site identification number	Sampling-site name	Contributing drainage area (square miles)	Stream classification for recreational purposes[1]
1	07144601	North Fork Ninnescah River at Arlington, Kansas	403	Noncontact
2	07144660	Silver Creek near Arlington, Kansas	193	Noncontact
3	07144680	Goose Creek near Arlington, Kansas	51.8	Noncontact
4	07144780	North Fork Ninnescah River near Pretty Prairie, Kansas	734	Noncontact
5	07144730	Red Rock Creek near Pretty Prairie, Kansas	53.2	Noncontact
6	07144795	North Fork Ninnescah River at Cheney Dam, Kansas	933	Noncontact

[1]From Kansas Department of Health and Environment (1997)

The sanitary quality of water and its use as a public drinking-water supply and for contact recreation can be evaluated on the basis of fecal coliform bacteria densities. Fecal coliform bacteria are indigenous to the intestinal tract of all warmblooded animals, and their presence indicates fecal contamination and the possible presence of pathogenic microorganisms, such as *entero-*, *rota-*, and *reovirus*, that may cause human diseases ranging from mild diarrhea to respiratory disease, meningitis, and polio (Pepper and others, 1996). Because of public-health concerns associated with fecal contamination, the Kansas Department of Health and Environment (KDHE) (1997) established a water-quality criterion of 2,000 col/100 mL (colonies per 100 milliliters) of water for noncontact recreation during stable, low-flow conditions (base flow). Noncontact recreation is recreational activities during which ingestion of surface water is not probable and includes, but is not limited to, wading, boating, fishing, trapping, and hunting (Kansas Department of Health and Environment, 1997). Streams tributary to Cheney Reservoir and the outflow downstream from the dam are classified for noncontact recreation (table 1). Cheney Reservoir is classified for full-body contact recreation and, as such, has a fecal coliform criterion of 200 col/100 mL of water (Kansas Department of Health and Environment, 1997). Possible sources of fecal coliform bacteria contamination include municipal-wastewater discharges, leachate from domestic septic systems, runoff or seepage from livestock-producing areas, and wildlife populations.

The objectives of the study presented in this fact sheet were to: (1) examine fecal coliform bacteria densities at six locations in the Cheney Reservoir watershed, (2) identify which streams, if any, have elevated densities that may pose potential concerns to drinking-water quality and human health associated with recreational activities, and (3) to evaluate these areas relative to State water-quality criteria for fecal coliform bacteria. The period of study included the water years 1997 and 1998 (October 1, 1996, through September 30, 1998).

Study Area

The Cheney Reservoir watershed has a contributing drainage area of approximately 933 square miles in parts of five south-central Kansas counties (fig. 1). The watershed consists of the North Fork Ninnescah River and associated tributary streams. The study area also includes Cheney Reservoir and its outflow to the North Fork Ninnescah River immediately downstream from Cheney Reservoir dam. Cheney Reservoir has a surface area of about 15 square miles, an average depth of about 16 feet, and a conservation pool storage of 151,800 acre-feet (Bureau of Reclamation, U.S. Department of the Interior, written commun., 1999).

Land use in the Cheney Reservoir watershed is primarily agricultural, and crop and livestock production is a major part of the economy. It has been estimated that about 52 percent of the watershed is cultivated, with the balance consisting of pastureland, forest cover, or small urban areas (Pope, 1998). Livestock production in the watershed consists mainly of cattle and hogs. Cattle and hog inventories in the watershed for 1996 were estimated previously at about 75,000 and 14,000 head, respectively (Pope, 1998). Livestock inventories by subbasin within the watershed currently (1999) are not available.

Human population in the watershed is less than 4,000, most of whom live on the approximately 1,000 farms in the watershed (Cheney Reservoir Watershed Task Force Committee, written commun., 1996). Populations of the six largest towns in the watershed range from less than 200 to slightly more than 1,200 people (Helyar, 1994).

In south-central Kansas, precipitation varies considerably throughout the year. The mean annual long-term (1961–90) precipitation is about 27 inches, most of which occurs during the growing season (April through September) (Kansas Department of Agriculture and U.S. Department of Agriculture, 1997, p. 8).

Methods

Hydrologic conditions within a watershed may affect the variability of many water-quality constituents, including fecal coliform bacteria. Therefore, a comparison of hydrologic conditions (mean annual streamflow) for water years investigated during this study (1997 and 1998) to long-term (1966–98) mean annual streamflow is warranted (fig. 2). Two of the sampling sites (sites 4 and 6, fig. 1) used in this study had a long-term record of streamflow. A comparison of annual mean streamflows at sampling site 4, the major inflow site to Cheney Reservoir, indicates that the 1998 water year (October 1, 1997, through September 30, 1998) had a larger mean streamflow (more rainfall/runoff during the year) than the 1997 water year (October 1, 1996, through September 30, 1997). Annual mean streamflows during both water years, however, were smaller than the long-term mean annual streamflow calculated for sampling site 4. The outflow from Cheney Reservoir, sampling site 6 (fig. 1), showed a similar relationship between the 1997 and 1998 water years, but annual mean streamflows for both years were larger than the long-term mean annual streamflow.

Stream-water samples for analysis of fecal coliform densities were collected manually at five sampling sites in the Cheney Reservoir watershed and at the reservoir outflow (fig. 1). These samples were collected in sterile bottles at the center of flow during both base-flow (sustained or fair-weather) and runoff conditions. Base-flow samples were collected about every month. An average of 15 samples were collected from each site during storm runoff throughout the sampling period. These samples represented seasonal and hydrologic differences. The samples were processed, and bacterial densities determined at the city of Wichita laboratory using a membrane filtration method (Method 9222) presented in Eaton and others (1995). Hydrologic conditions were evaluated on the basis of a continuous record of streamflow at each sampling site.

Occurrence of Fecal Coliform Bacteria

Variability in fecal coliform densities was greatest in water samples collected during runoff conditions at all sampling sites upstream from Cheney Reservoir (fig. 3). Outflow of Cheney Reservoir (sampling site 6) is completely regulated, and therefore, no distinction was made between base-flow and runoff conditions for this site. Fecal coliform densities greater than 10,000 col/100 mL of water were not uncommon during runoff conditions in the watershed. The maximum density determined during runoff conditions in the 1997–98 water years was 36,000 col/100 mL of water from Red Rock Creek near Pretty Prairie (sampling site 5, fig. 1). In contrast, the maximum fecal coliform density determined during base-flow conditions was 1,990 col/100 mL of water from Silver Creek near Arlington (sampling site 2, fig. 1). The smallest variation in fecal coliform densities occurred in water from sampling site 4 (range of 2 to 400 col/100 mL of water) during base flow and in water from sampling site 6, the outflow of Cheney Reservoir (range of 1 to 460 col/100 mL of water).

Fecal coliform densities are typically much greater in streams during runoff conditions because of nonpoint-source contributions from the watershed. These contributions can originate from deposition of fecal material by livestock (pastured or confined), from the use of manure as a soil amendment, or possibly from leachate from antiquated domestic septic systems. The increase in fecal contamination of surface water during runoff has been documented previously in other parts of Kansas in both agricultural (Pope, 1995) and urban environments (Pope and Putnam, 1997).

Median densities of fecal coliform bacteria in water samples collected during base flow were larger for the 1998 water year than for the 1997 water year at all sampling sites in the Cheney Reservoir watershed except at sampling sites 4 and 6 (fig. 4). The median density is a measure of the central tendency of the data and is that value in an ordered set of data above and below which there is an equal number of values. Median densities during base flow for the 1997 water year at the five sampling sites upstream from Cheney Reservoir (fig. 1) ranged from 152 col/100 mL of water at sampling site 1 (North Fork Ninnescah River at Arlington) to 332 col/100 mL of water at sampling site 3 (Goose Creek near Arlington). Similarly, median densities in the 1998 water year ranged from 204 col/100 mL of water at sampling site 4 (North Fork Ninnescah River near Pretty Prairie) to 440 col/100 mL at sampling site 3. Median densities in water samples from sampling site 6 (outflow of

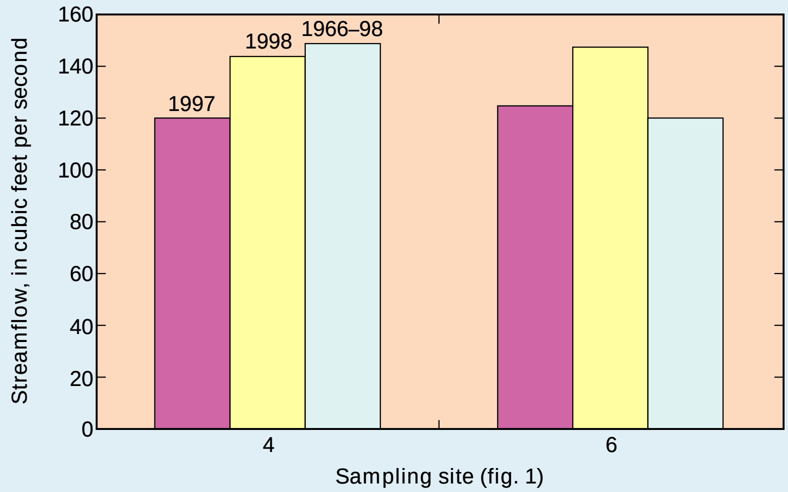

Figure 2. Comparison of annual mean streamflows for 1997 and 1998 water years and mean annual streamflow for 1966–98 water years at sampling sites 4 and 6.

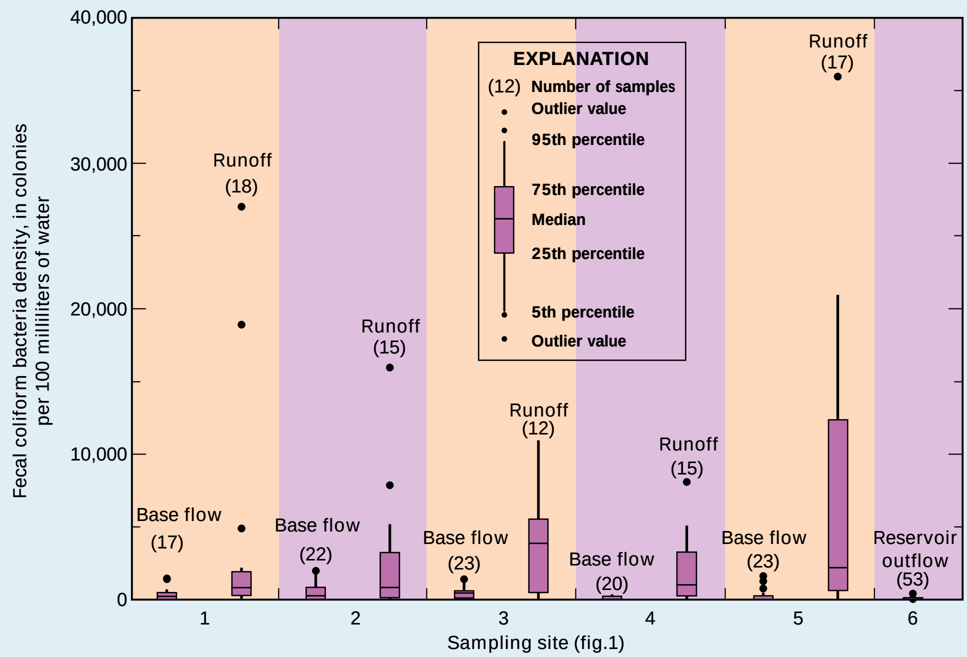

Figure 3. Distribution of fecal coliform densities in water from sampling sites in Cheney Reservoir watershed during base-flow and runoff conditions for 1997–98 water years.

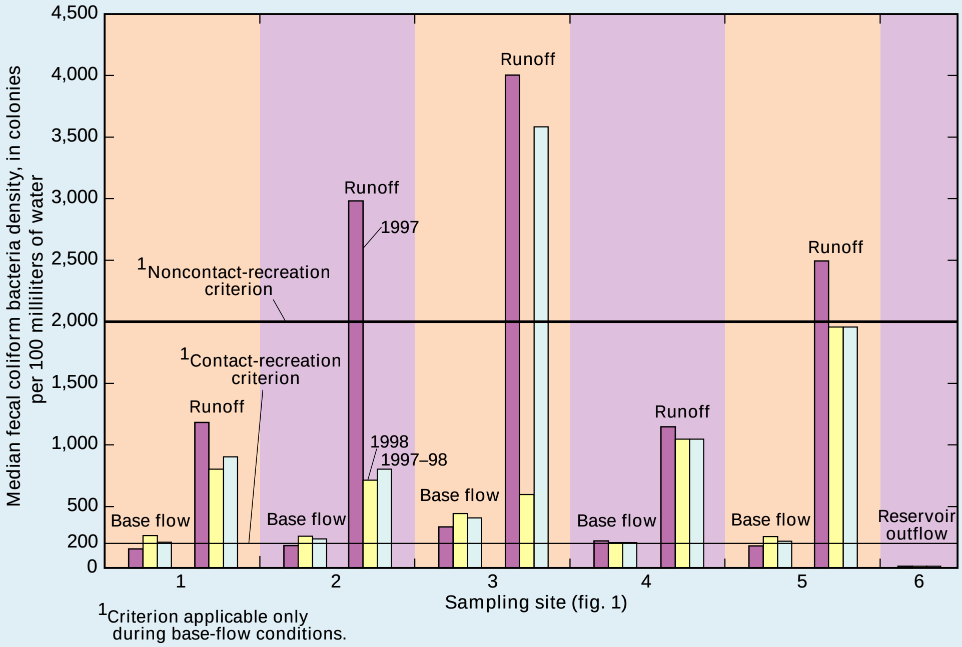

Figure 4. Comparison of median densities of fecal coliform bacteria in water from sampling sites in Cheney Reservoir watershed during base-flow and runoff conditions for 1997–98 water years (noncontact- and contact-recreation criteria from Kansas Department of Health and Environment, 1997).

Cheney Reservoir) were 12 col/100 mL of water for the 1997 water year and 10 col/100 mL for the 1998 water year.

Current (1999) water-quality criteria for fecal coliform bacteria apply to stable, low-flow (base-flow) periods (Kansas Department of Health and Environment, 1997). The criterion of 2,000 col/100 mL of water for noncontact recreation (Kansas Department of Health and Environment, 1997) was not exceeded in any of the base-flow samples collected. Median fecal coliform bacteria densities in stream-water samples collected during runoff conditions were substantially larger than in samples collected during base-flow conditions (fig. 4).

Conclusions and Implications

Median fecal coliform bacteria densities in samples of base flow from the five sampling sites upstream from Cheney Reservoir (sites 1–5, fig. 1) were, on average, 34 percent larger for the 1998 water year than for the 1997 water year. The reason for this difference is unclear but probably is related to differences in and natural variability in hydrologic conditions between the two years (fig. 2), assuming similar land-use and land-management conditions. It is unlikely that land-use and land-management conditions changed during such a short period of time (between the 1997 and 1998 water years) to the extent necessary to create the documented differences in fecal coliform densities.

Median fecal coliform bacteria densities in samples of base flow for both the 1997 and 1998 water years did not exceed water-quality criterion for noncontact recreation, which is the classified use of the streams at all sampling sites in the Cheney Reservoir watershed. Median fecal coliform bacteria densities in samples during runoff conditions at the five sampling sites upstream from Cheney Reservoir were many times larger than median densities in samples during base-flow conditions; however, no standards are established for runoff conditions. Generally, the quality of water in a reservoir may be determined more by the quality of its watershed runoff than by its base flow because the majority (largest volume) of the impounded water enters the reservoir during runoff periods.

The implication of large median densities in tributary streams might be to expect large densities within Cheney Reservoir. The relatively small densities of fecal coliform bacteria in the outflow of Cheney Reservoir are attributed to the fact that bacteria are a nonconservative (subject to degradation) water-quality constituent. Bacteria are subject to die off and predation by other organisms. The physical processes of dilution by reservoir water and deposition also play a role in decreasing in-lake bacterial densities.

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